Approach for the long-term spatial and temporal evaluation of ocean color data products in the Chesapeake Bay

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why monitor Chesapeake Bay water quality?

excessive nutrient (N, P) input into the Bay from agriculture and other land use

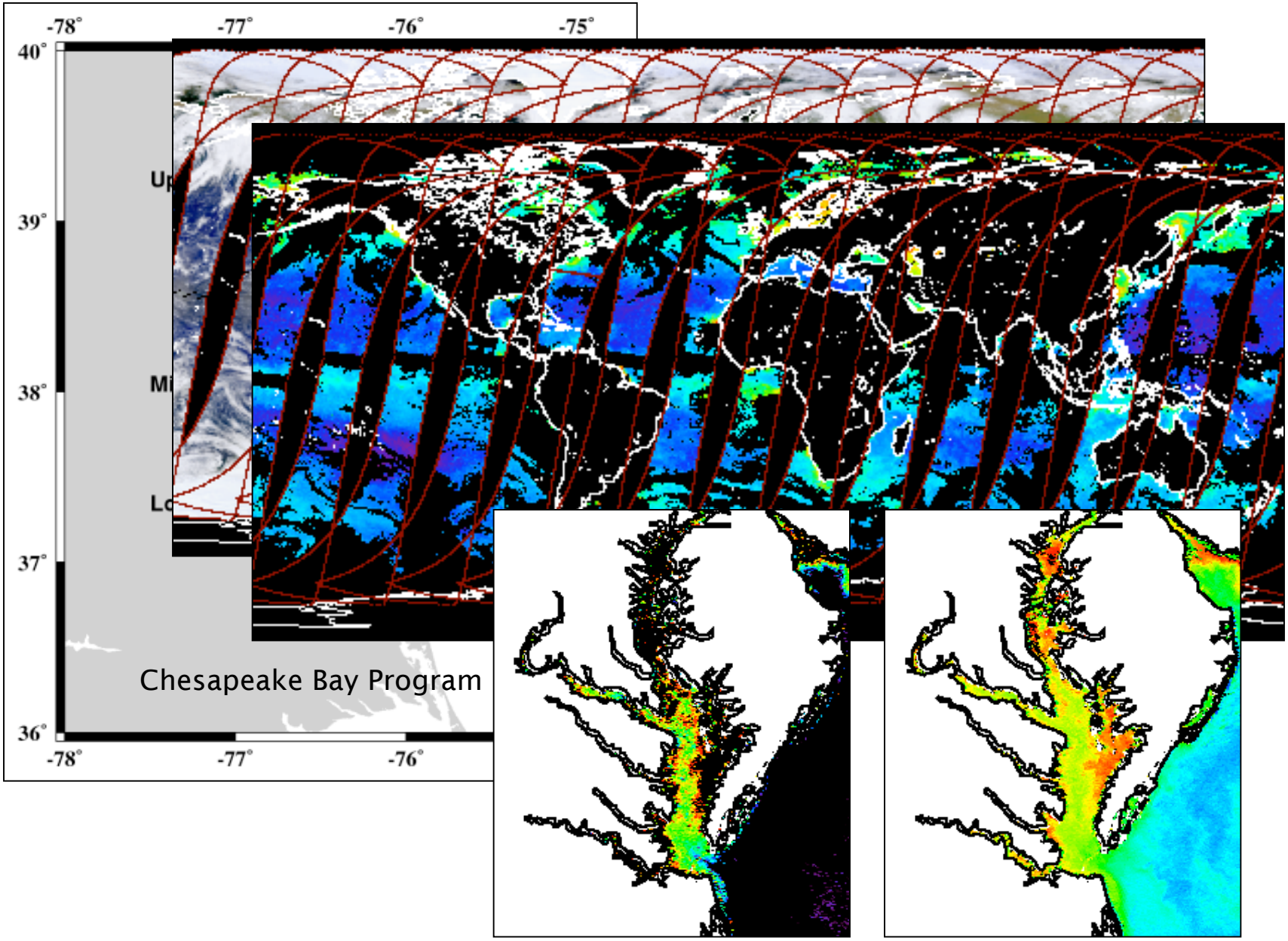
- stimulates phytoplankton blooms
  - algae die, sink, and are broken down by microbial activity
    - this depletes oxygen and creates dead “hypoxic” zones
      - detrimental to fish and shellfish populations
  - “eutrophication”

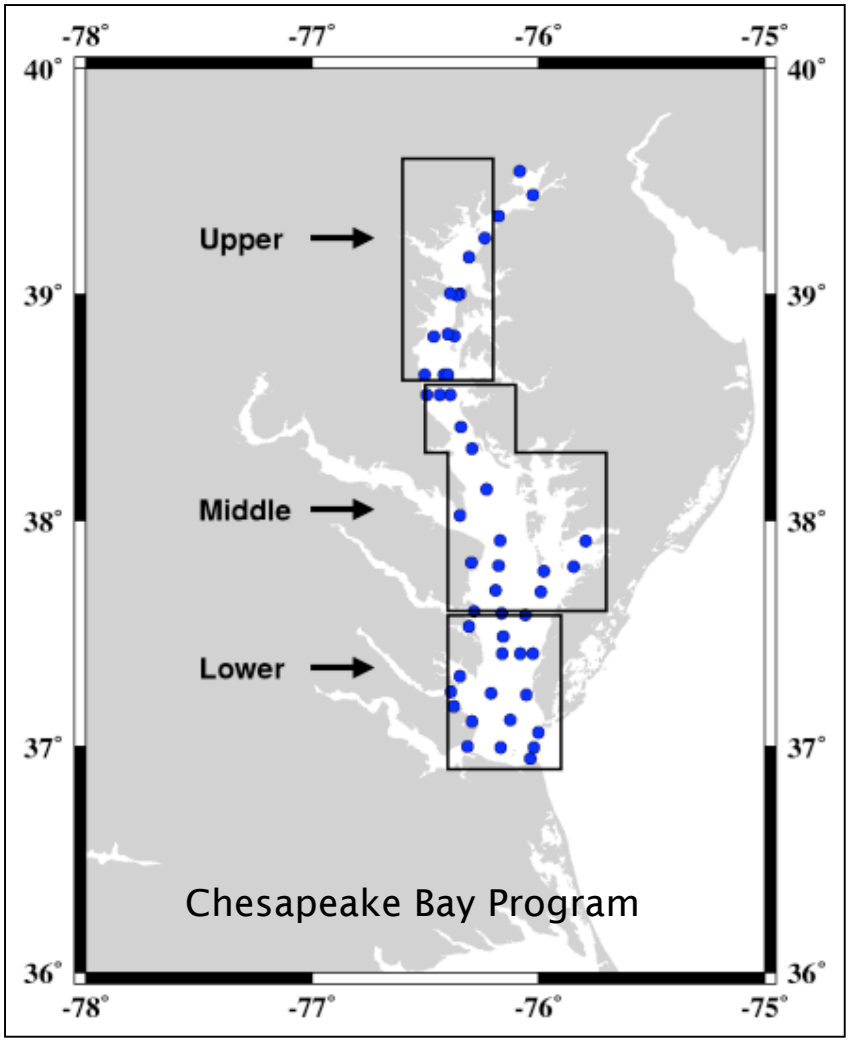
- increased turbidity inhibits sunlight from reaching the sea floor
  - suppresses growth of sea grasses
    - provide fish and shellfish habitats
    - stabilize bottom sediments
    - reduce shoreline erosion
    - filter nutrients (retained as plant material)

routine monitoring underway and regulatory action proposed

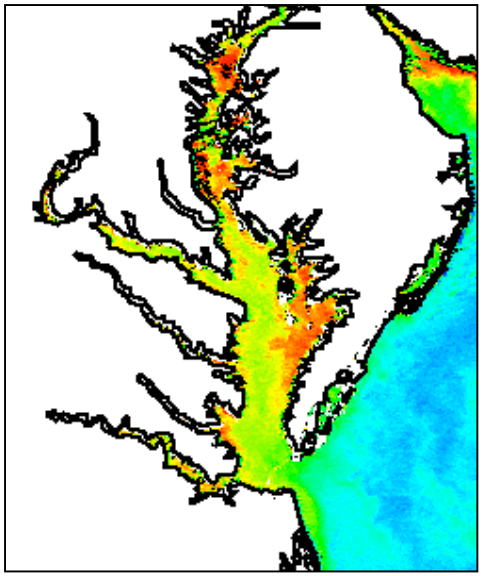
Chesapeake Bay Program (http://www.chesapeakebay.net)

why supplement *in situ* sampling with satellite data products?

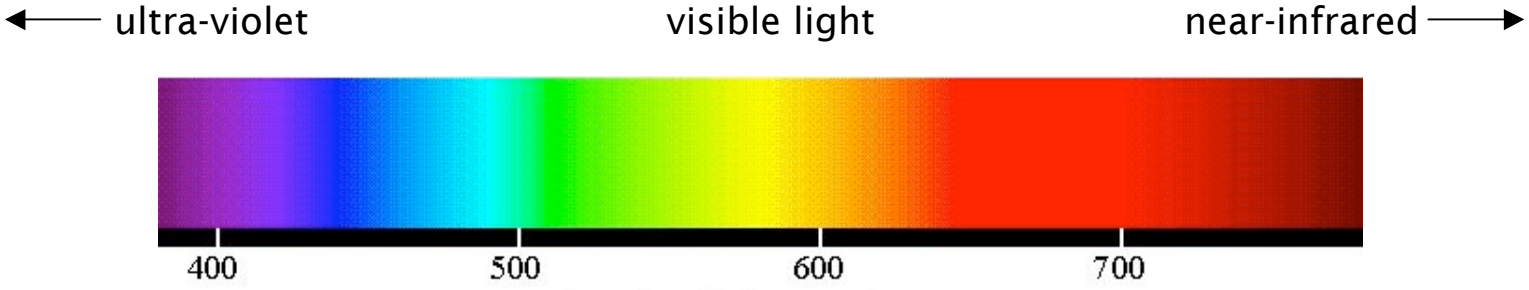

-78°
-77°
-76°
-75°
40°
39°
38°
37°
36°
Chesapeake Bay Program



complementary data sets?

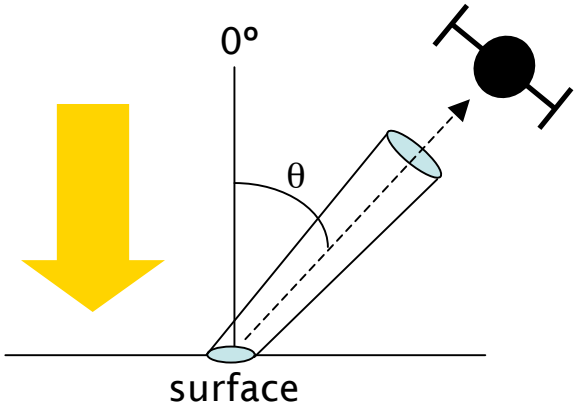


what are the challenges associated with satellite ocean color?



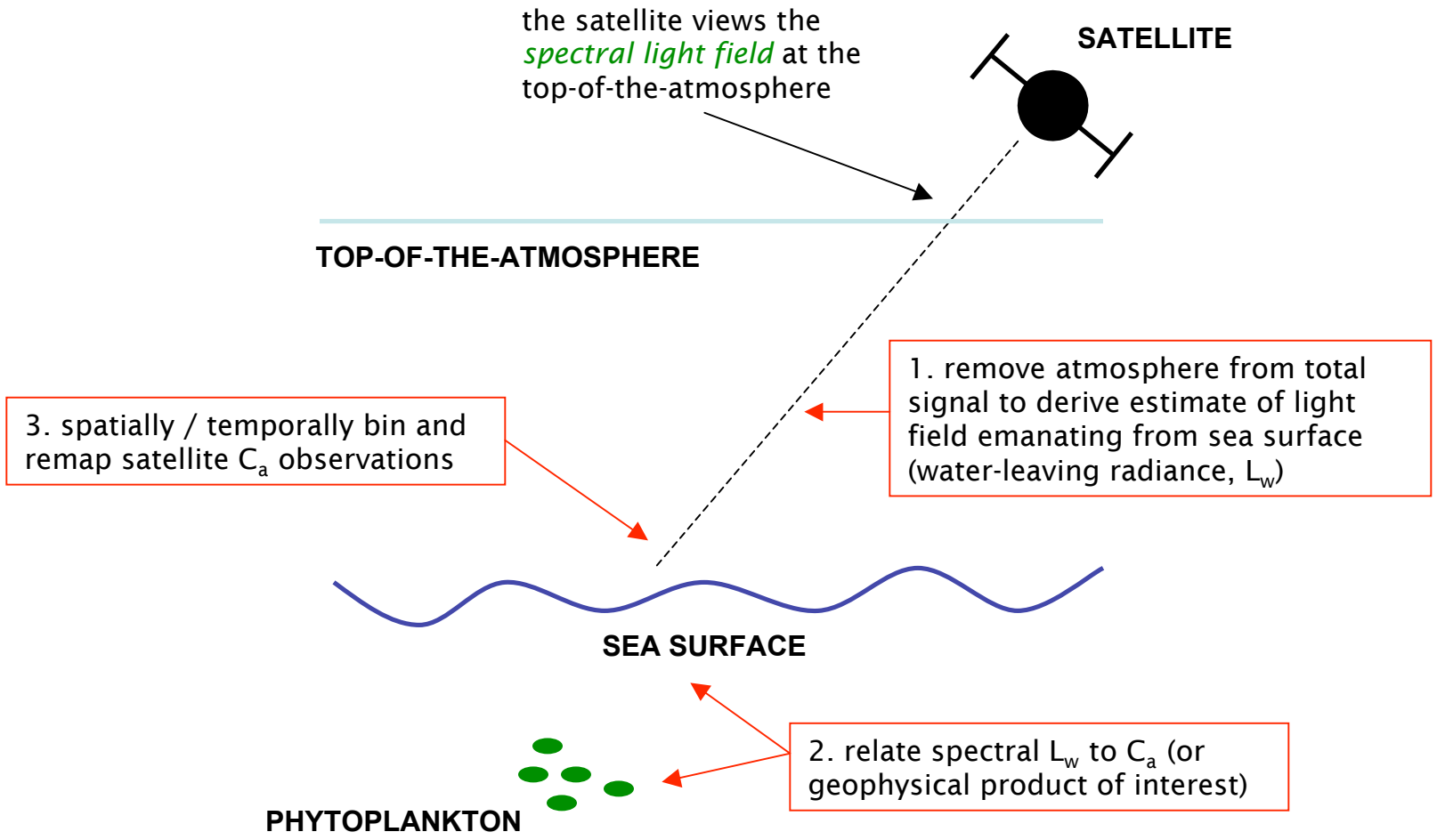
412 443 490 510 555 670 765 865

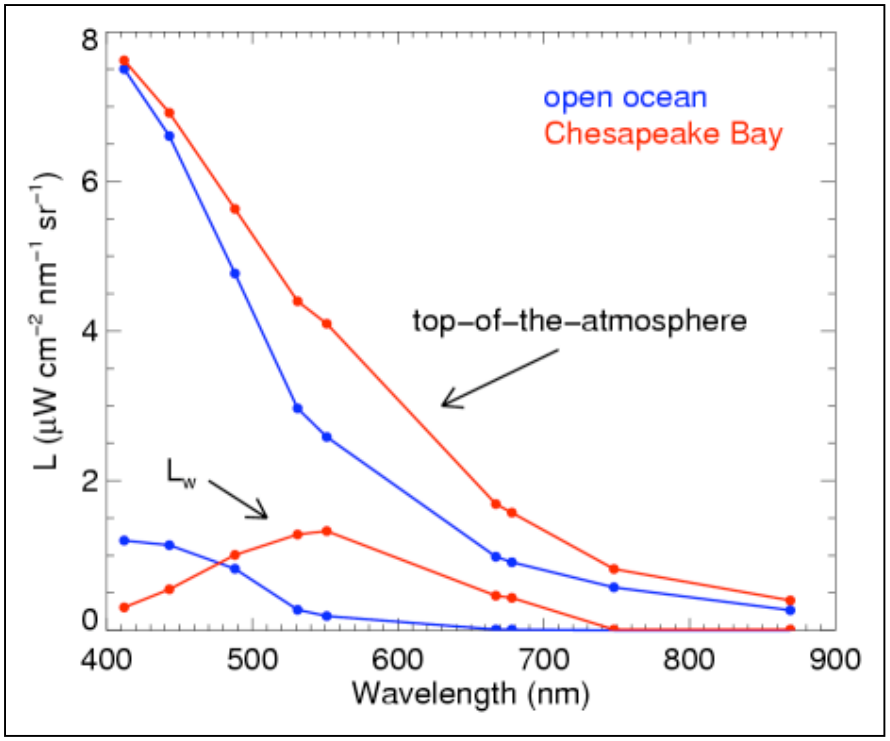
8 SeaWiFS channels



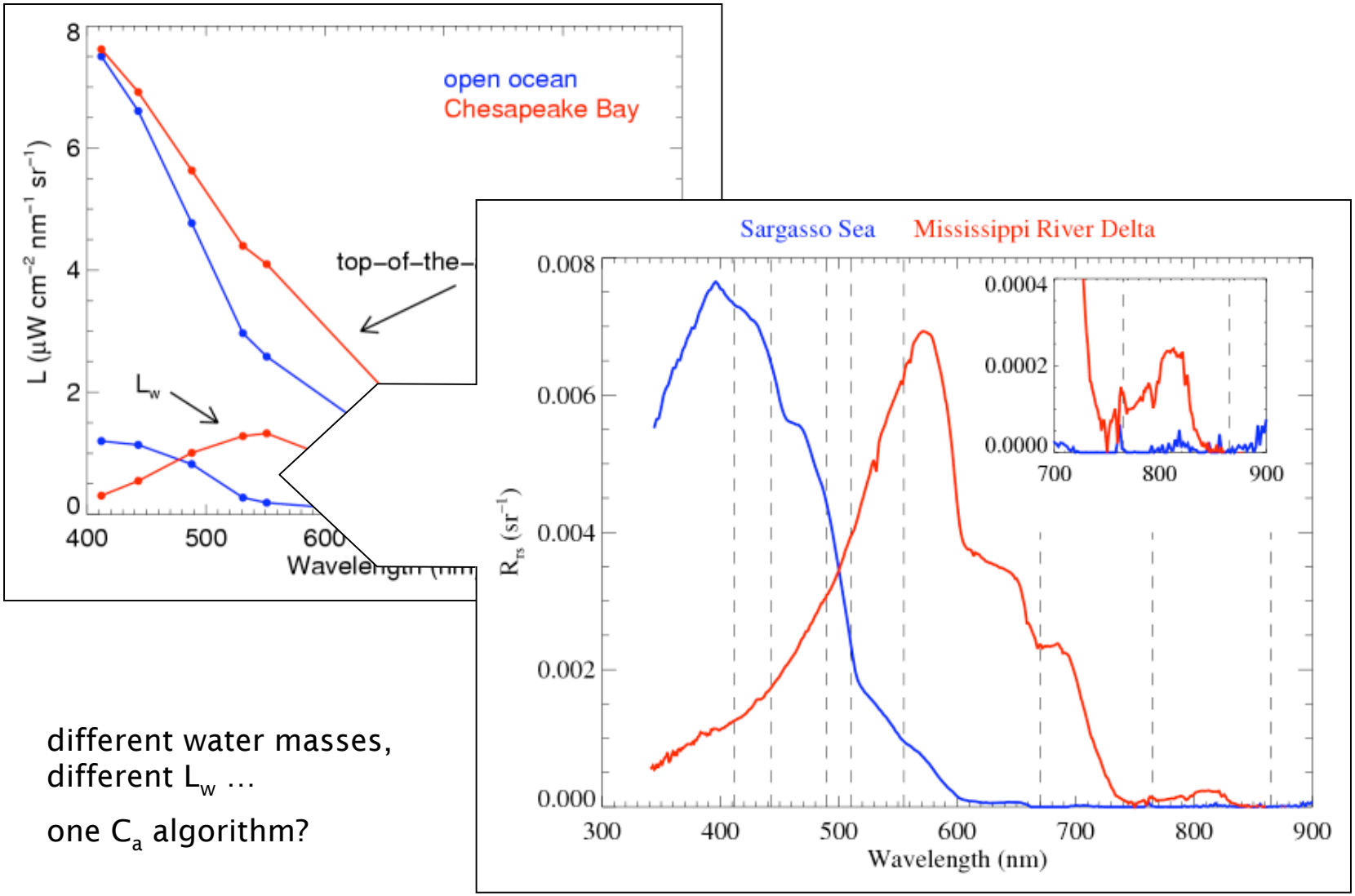
radiance, L, in units of $\mu W\ cm^{-2}\ nm^{-1}\ sr^{-1}$

$$\text{reflectance, } R = \frac{L}{\text{incident irradiance, } E}$$


the satellite views the
spectral light field at the
top-of-the-atmosphere
SATELLITE
TOP-OF-THE-ATMOSPHERE
1. remove atmosphere from total signal to derive estimate of light field emanating from sea surface (water-leaving radiance, L_w)
3. spatially / temporally bin and remap satellite C_a observations
SEA SURFACE
2. relate spectral L_w to C_a (or geophysical product of interest)
PHYTOPLANKTON



atmosphere is 80-90% of the total top-of-atmosphere signal in blue-green wavelengths (400-600 nm)



different water masses,
different L_w …

one C_a algorithm?

some challenges to remote sensing of coastal and inland waters:

temporal and spatial variability
- limitations of satellite sensor resolution and repeat frequency
- validity of ancillary data (reference SST, wind)
- varied resolution requirements and binning options

straylight contamination from land

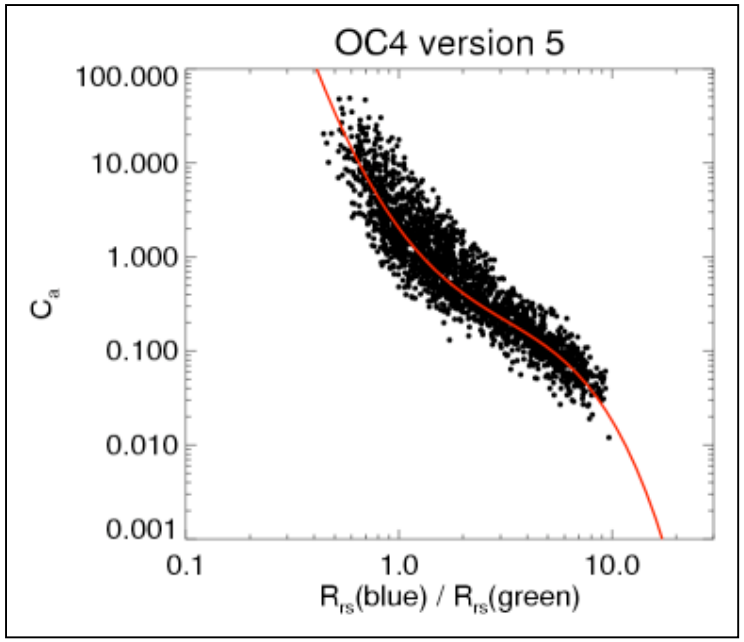
non-maritime aerosols (dust, pollution)
- region-specific models required
- absorbing aerosols

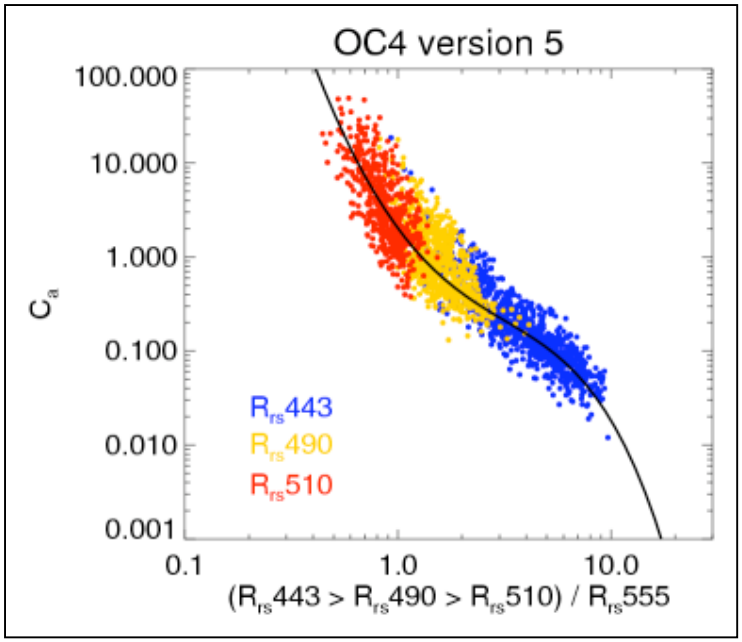
suspended sediments and CDOM
- complicates estimation of L_w(NIR), model not a function of C_a
- complicates correction for non-uniform subsurface light field (f/Q)
- saturation of observed radiances

anthropogenic emissions (NO_2 absorption)

what algorithms are available?

1. empirical (statistical) algorithms





2. semi-analytical algorithms

photons have two fates when they travel through a medium:

(1) absorbed, *a*
(2) scattered, *b* (backwards, b_b)

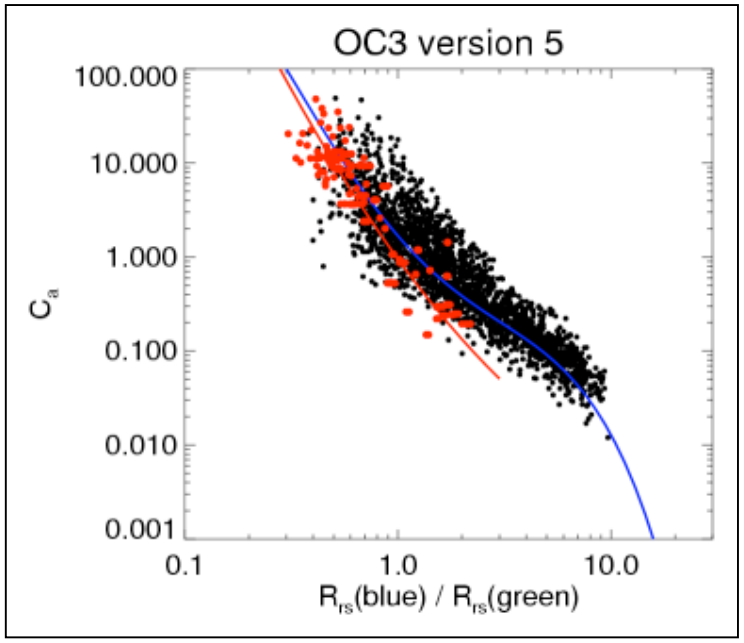
$$R_{rs}(\lambda) \approx \frac{b_b(\lambda)}{a(\lambda)}$$

$$R_{rs}(\lambda) \rightarrow b_b, a \rightarrow C_a$$

least squares — empirical

1. empirical (statistical) algorithms

regional tuning?



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least squares

empirical

what has the NASA Ocean Biology Processing Group done to help so far?

PROCESSING

3,000 MODIS-Aqua & 6,200 SeaWiFS files acquired
processed from Level-1A (TOA) to Level-2 (L_w)
statistical and visual QC applied
1,107 SeaWiFS scenes from Sep 97 to Mar 07
537 MODIS-Aqua scenes from Jun 02 to Mar 07
nine days of data per month for each sensor

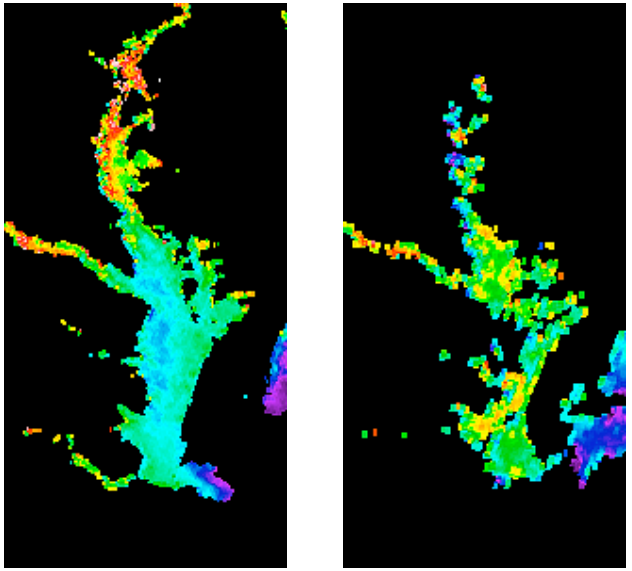
COMPARISON TO GROUND TRUTH

data distributions via histograms
time-series (monthly averages)
match-ups with Level-2 data

STRATIFICATION

spatially: upper, middle and lower Bay
temporally: Winter, Spring, Summer, Fall

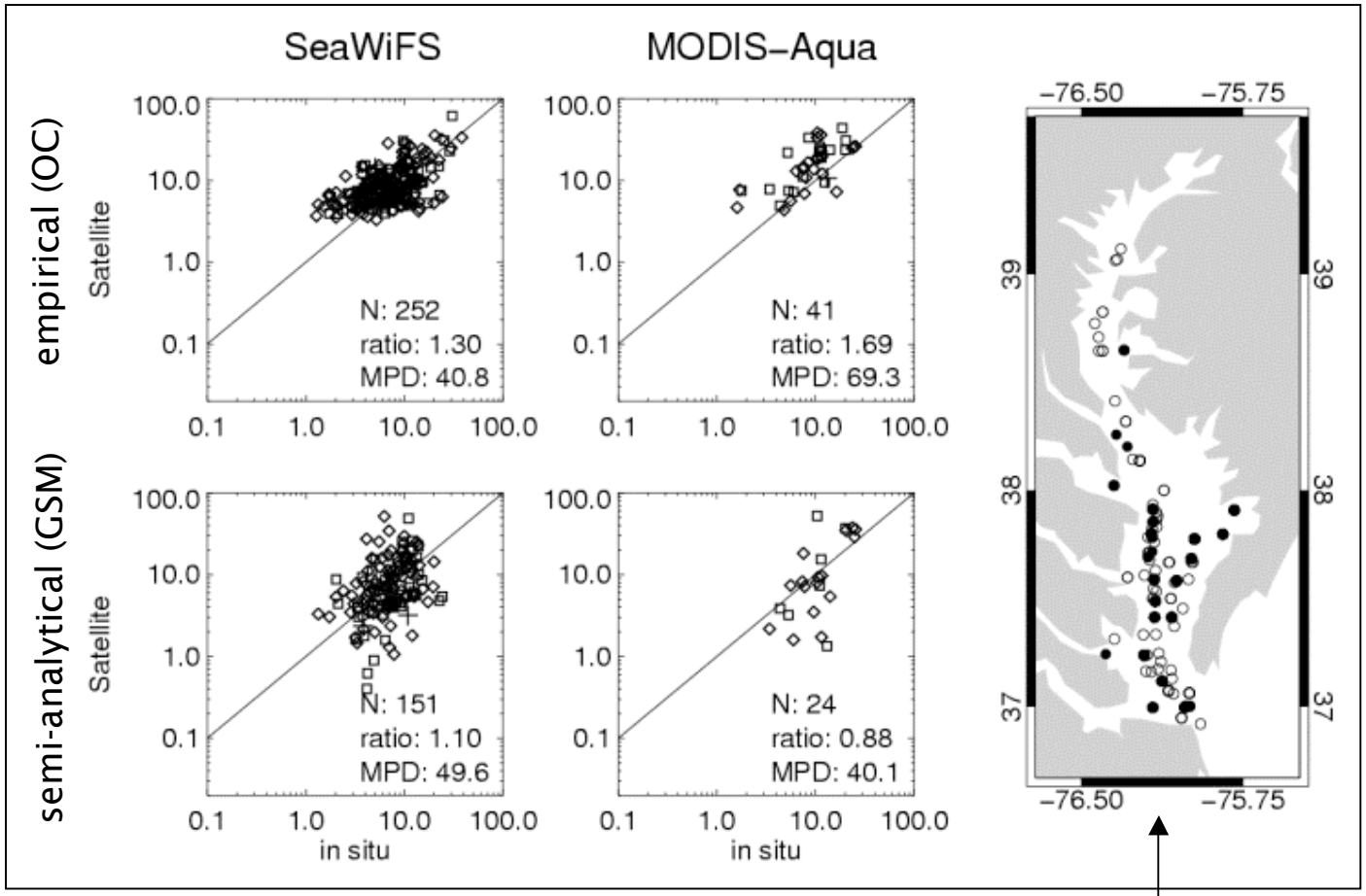
QUALITY CONTROL



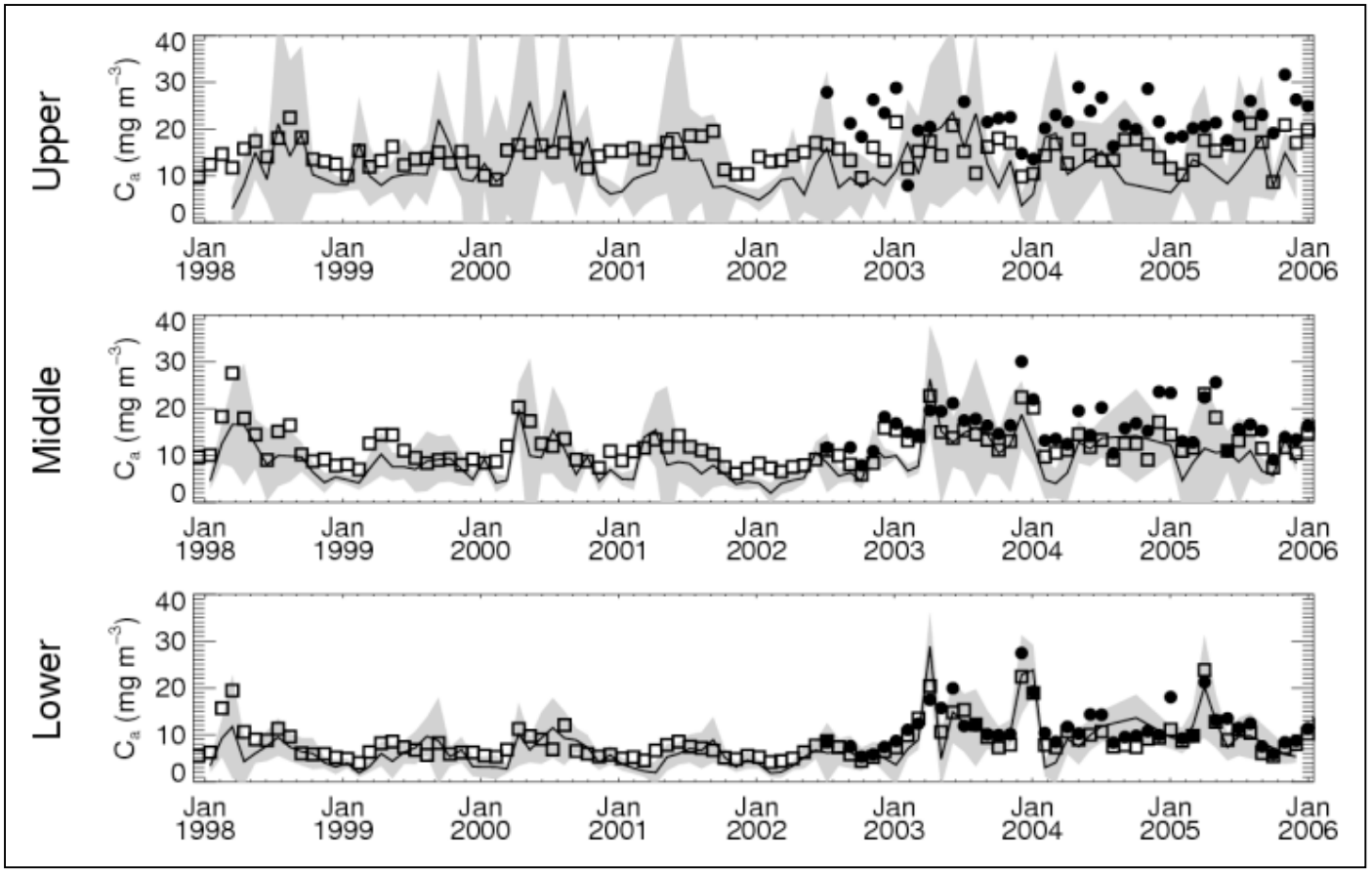
GOOD BAD

eliminate scenes with high sat zenith
require >25% of Bay ocean pixels to be cloud free
visual inspection
consider only $0.1 < C_a < 100$ mg m^{-3}
require >200 valid pixels per region per scene

in situ vs. satellite “match-ups” (coincident observations compared)

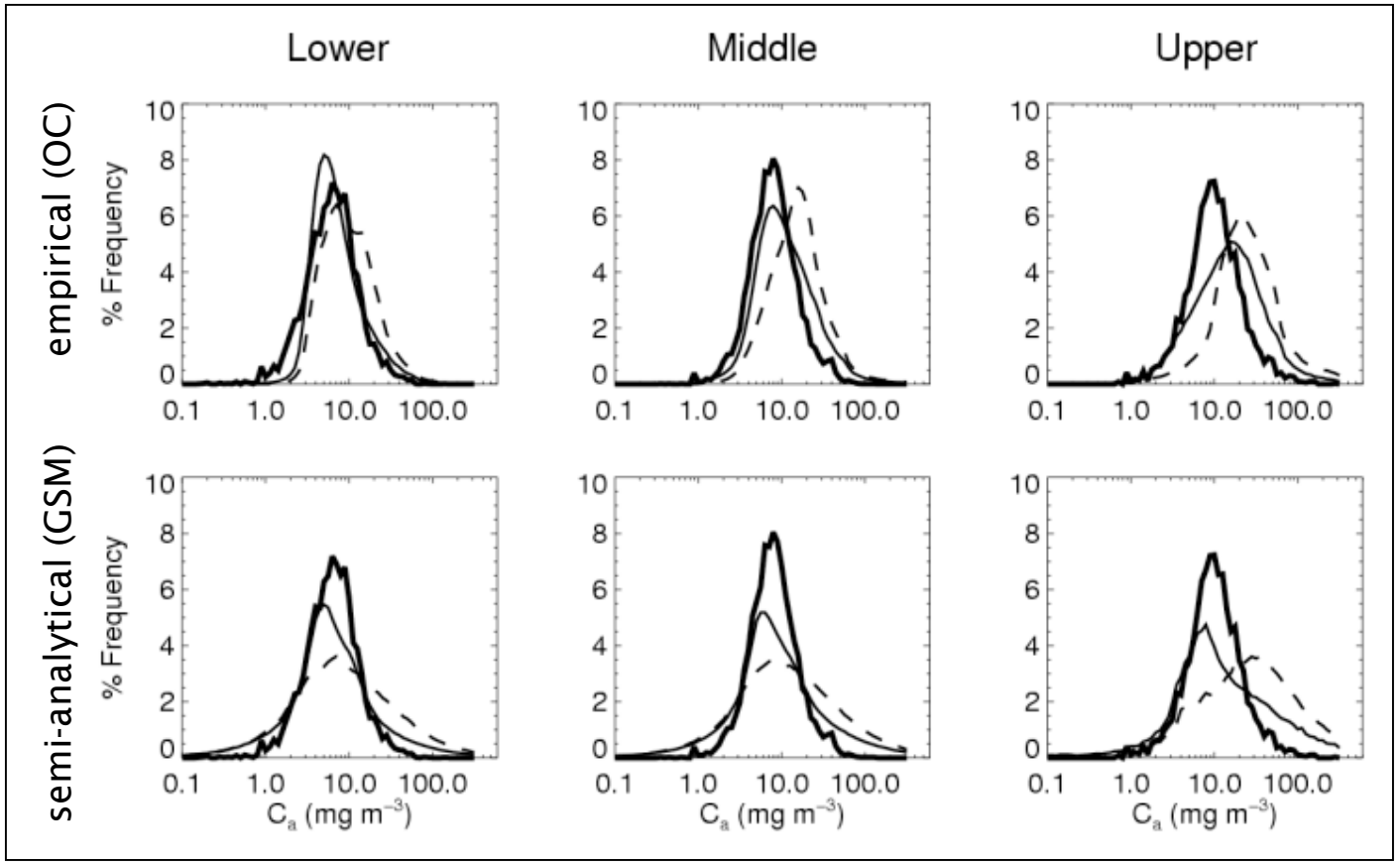


long-term time-series using monthly averages

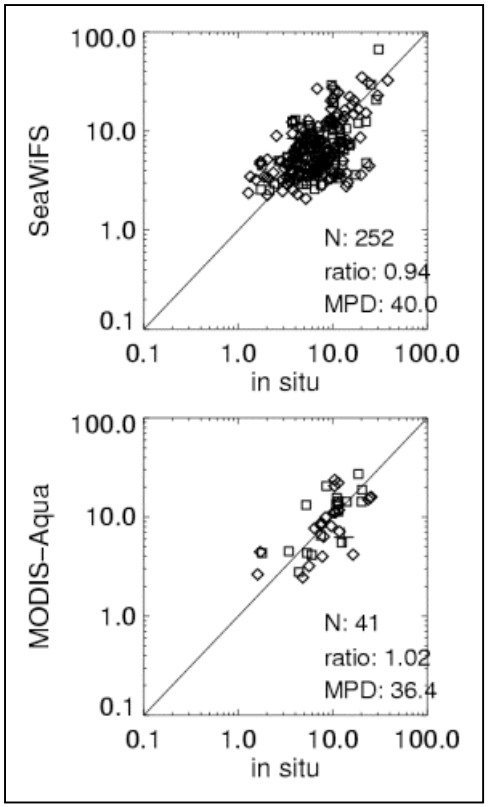


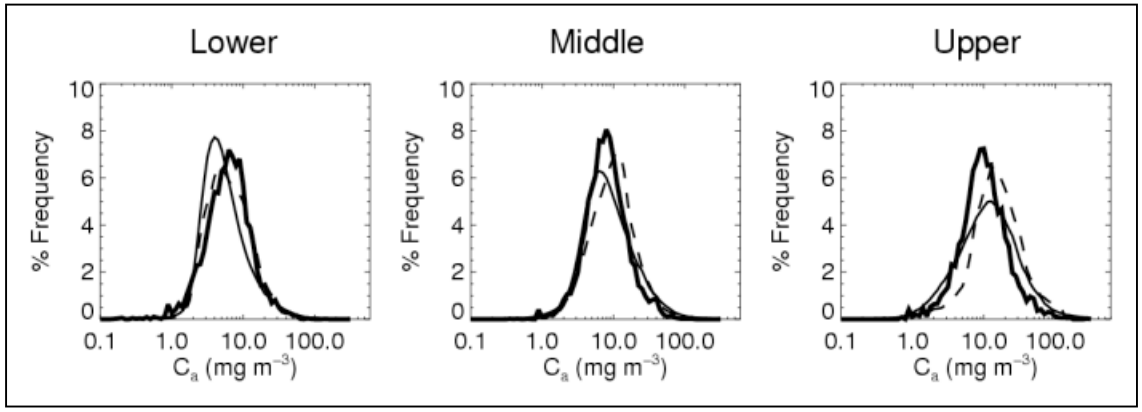
SeaWiFS
MODIS-Aqua
in situ median
in situ std dev

data distributions with all seasons considered



evaluation of regional algorithms





example empirical approaches:

(1) regional correction to global algorithm

(2) regionally-derived algorithm using in situ data

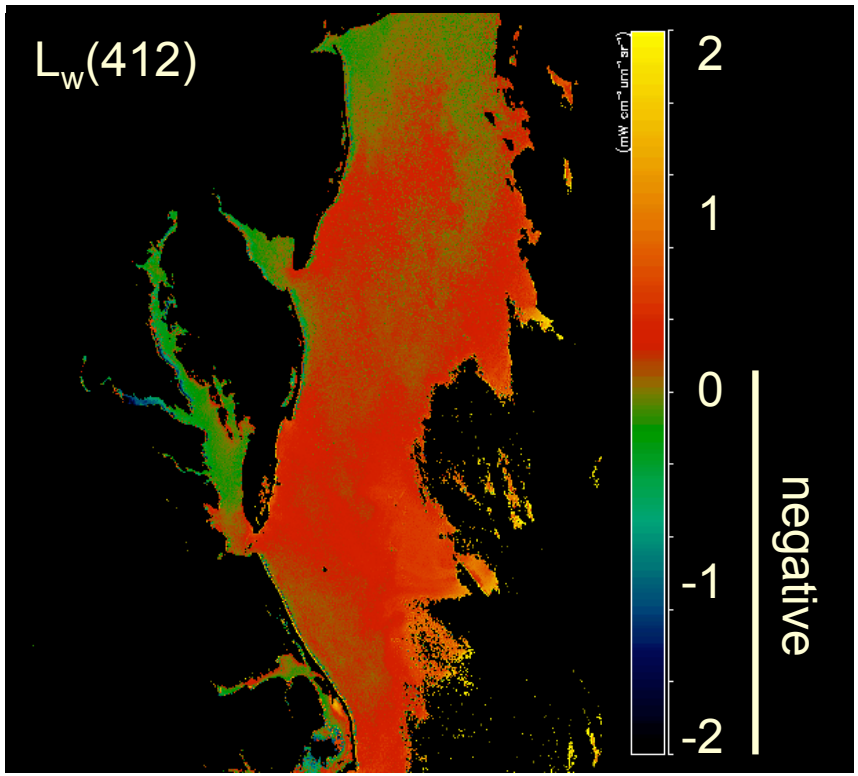
(3) regionally-derived algorithm using satellite data

absolute percent differences derived from histograms

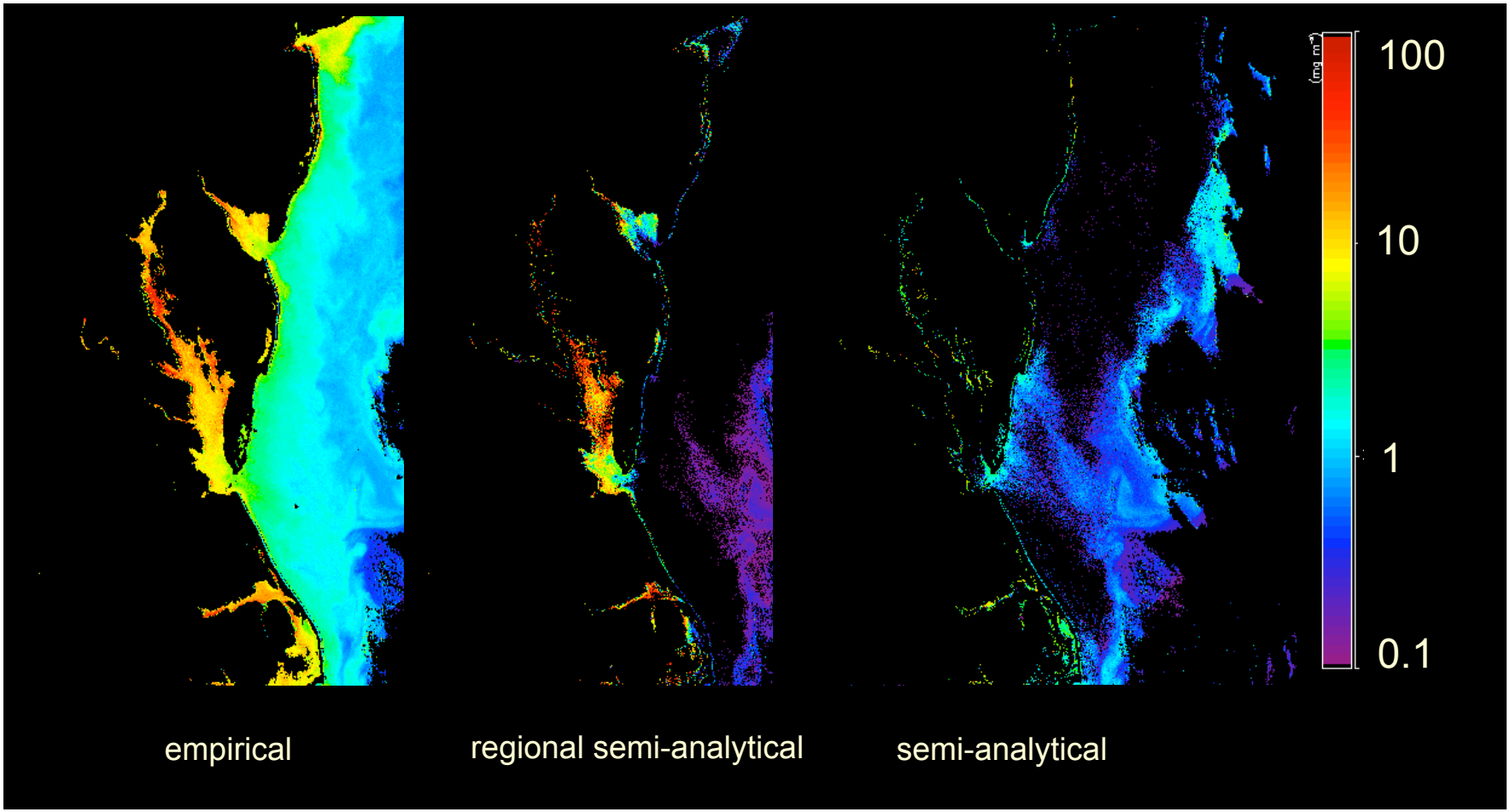
		N	OC3	OC3-CB	GSM	GSM-CB
	Spring	1208	85.7	63.8	85.2	**63.4** ●
Upper	Summer	1364	44.4	20.8	119.2	**3.3** ●
Bay	Fall	374	100.6	75.0	**64.6** ●	82.4
	Winter	717	91.7	68.2	79.9	**62.8** ●
	Spring	1752	65.4	39.8	104.0	**33.9** ●
Middle	Summer	1986	51.3	**24.6** ●	78.5	58.1
Bay	Fall	808	76.3	45.1	87.8	**24.7** ●
	Winter	1268	91.0	65.4	85.9	**45.4** ●
	Spring	1993	65.7	**33.0** ●	95.6	38.1
Lower	Summer	2532	45.2	**10.6** ●	75.6	58.5
Bay	Fall	1142	45.6	**6.1** ●	115.9	9.4
	Winter	1537	85.6	54.2	111.5	**45.9** ●

OC = empirical GSM = semi-analytical -CB = regional algorithm

does coverage vary by algorithm?



yes, coverage varies by algorithm



working with the Chesapeake Bay Program since Feb 2006

collaborators: EPA, Maryland and Virginia DNR, NOAA, ODU, and UMD

"round robin" for 9 candidate C_a algorithms (global and regional)

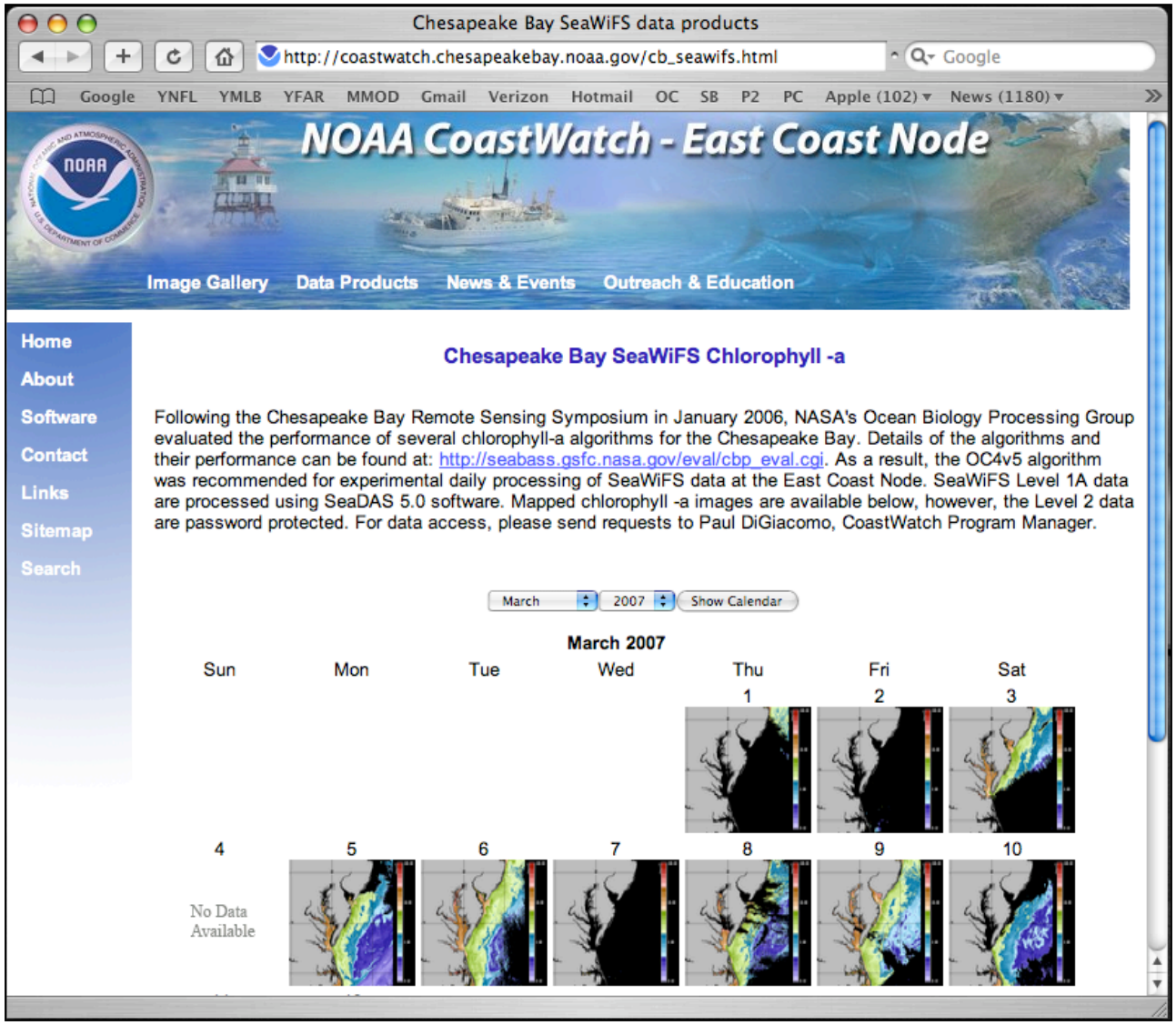
initiated with SeaWiFS, later extended to MODIS-Aqua

results presented in Jul 2006 and Apr 2007

http://seabass.gsfc.nasa.gov/eval/cbp_eval.cgi

exploring use of:

- MODIS land bands (250 and 500-m spatial resolution)
- alternate atmospheric correction approaches
- alternate aerosol models
- complementary in situ aerosol data (AERONET)
- alternate products (a and b_b) as proxies for C_a


Chesapeake Bay SeaWiFS data products
http://coastwatch.chesapeakebay.noaa.gov/cb_seawifs.html
Google
YNFL YMLB YFAR MMOD Gmail Verizon Hotmail OC SB P2 PC Apple (102) News (1180)
NOAA CoastWatch - East Coast Node
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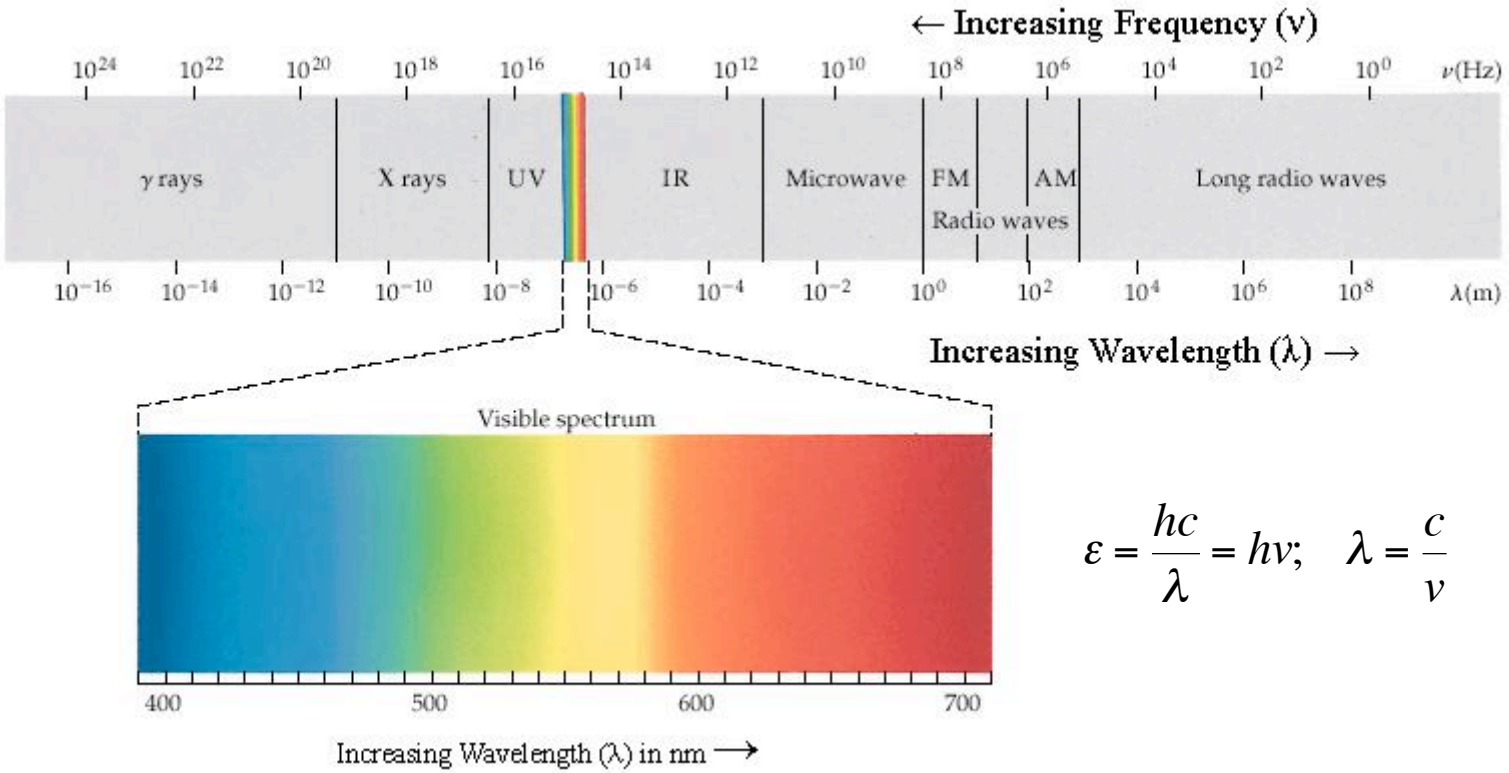
Chesapeake Bay SeaWiFS Chlorophyll -a
Following the Chesapeake Bay Remote Sensing Symposium in January 2006, NASA's Ocean Biology Processing Group evaluated the performance of several chlorophyll-a algorithms for the Chesapeake Bay. Details of the algorithms and their performance can be found at: http://seabass.gsfc.nasa.gov/eval/cbp_eval.cgi. As a result, the OC4v5 algorithm was recommended for experimental daily processing of SeaWiFS data at the East Coast Node. SeaWiFS Level 1A data are processed using SeaDAS 5.0 software. Mapped chlorophyll -a images are available below, however, the Level 2 data are password protected. For data access, please send requests to Paul DiGiacomo, CoastWatch Program Manager.
March
2007
Show Calendar
March 2007
Sun Mon Tue Wed Thu Fri Sat
1 2 3
4 5 6 7 8 9 10
No Data Available

NASA Ocean Biology Processing Group ~ PJW, SSAI, 10 Oct 2007

the electromagnetic spectrum



$$\varepsilon = \frac{hc}{\lambda} = h\nu; \quad \lambda = \frac{c}{\nu}$$

top-of-the-atmosphere radiance